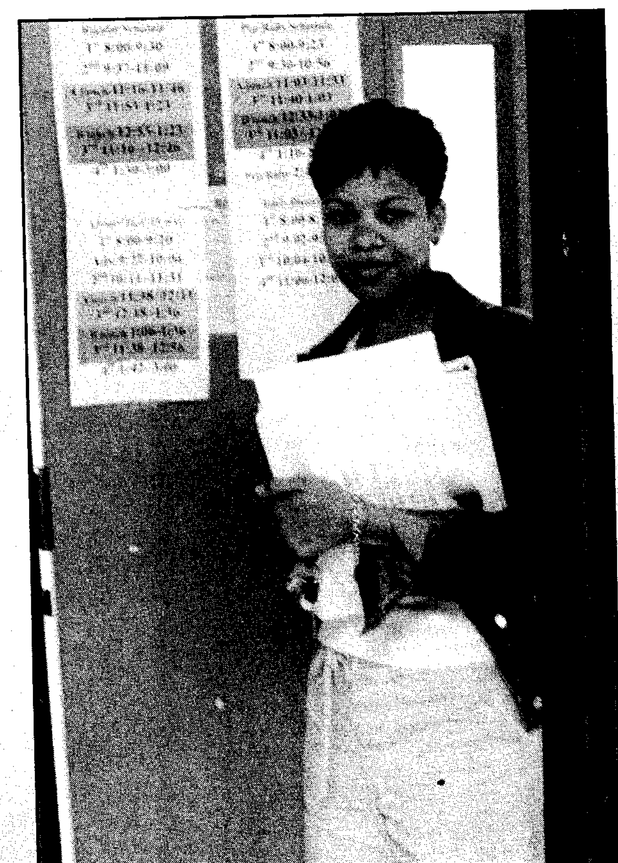
chapter 3

Planning to Teach Science



Beginning teachers must take time for planning in order to be successful.

Chiapetta, E.L., Koballa, Thomas R. (2006) Science Instruction in the Middle & Secondary Schools. 6th Ed : Person Merril Prentice Hall: Columbus, OH.

Mrs. Leticia Jones is a first-year biology teacher at a large urban high school. She has had a few education courses and has been given a temporary teaching permit with the expectation that she will complete her certification program in the first 3 years of teaching in the district. Mrs. Jones is working after school with her mentor teacher, Mr. Michael Thanos, who has been a biology teacher in that school for over 30 years. Mr. Thanos has mentored many new teachers during his career and often has a student teacher in his classroom. Let's listen in on a conversation between the novice teacher and the experienced teacher.*

This logo appears throughout the chapter to indicate where vignettes are integrated with chapter content.

Mr. Thanos: *Mrs. Jones, we are about to begin teaching about the cell, which is used as a foundational topic for the rest of the biology course. What are your thoughts on how to teach this unit?*

Mrs. Jones: *I would like to begin by teaching about the discovery of cells, cell structure and function, and cytoplasmic organelles. Then move on to energy, photosynthesis, glycolysis, respiration, and fermentation. If the kids know this material, they can build on this knowledge.*

Mr. Thanos: *How long will you spend on this?*

Mrs. Jones: *I can probably cover this in 6 or 7 days. There is a great deal to cover this semester, and I must cover this material quickly. My friend Alice teaches biology at the other high school, and that is what she does.*

Mr. Thanos: *Yes, I know Alice. She has been teaching for a long time, and I believe the biology teachers in that school have a different approach to biology course instruction than some of us in this school. Further, there is a different student population in that school. The students in this school are much more diverse. There are over 20 different languages and dialects spoken by students in this high school. Do you have time for me to describe how I would approach the cell unit, given the students that you have in your classes?*

Mrs. Jones: *Sure, but I don't have a lot of time this afternoon because I have to pick up my daughter from day care, and then I have choir practice at the church this evening.*

Mr. Thanos: *Okay! Let's get started on this unit. What activity might you begin with to capture the interest of the students?*

Mrs. Jones: *Well, you know, I would draw a cell on the board and ask the students to help me label the structures.*

Mr. Thanos: *I have taken that approach at times. How about an activity that would immediately get the students engaged and connected to what they are about to learn with what they already know? Give this some thought while I go to my classroom and get some materials that you may find useful for initiating the study of cells. Please make a list of instructional activities that would interest your students in learning about cells.*

After about 5 minutes, Mr. Thanos returned with a box of folders, handouts, and lab materials.

Mr. Thanos: *Leticia, what have you come up with?*

Mrs. Jones: *I didn't get very far because my cell phone rang. It was my sister telling me she could not babysit this evening while I'm at choir practice. I will have to find someone else to watch my daughter this evening. Back to my ideas about biology class, I do have one idea. I could demonstrate osmosis. That experiment always gets students' attention.*

Mr. Thanos: *Good, I like that idea. Let me tell you how you might build up to osmosis by beginning with cell structure and function. Here, take this chicken's egg. What is there about this egg that might relate to the structure of a biological cell?*

Mrs. Jones: *Well, the shell could represent the cell wall or membrane.*

Mr. Thanos: *Break the egg into this Petri dish, and let's examine all of the parts that we can observe. What do you see under the shell?*

Mrs. Jones: *Oh! I see a membrane under the shell.*

Mr. Thanos: *That is correct. It is the shell membrane, and you can demonstrate osmosis with that structure. Can you tell me what the yellow and white materials are and what part of the cell they represent? Also, is there a visible structure that represents the nucleus?*

Mrs. Jones: *I never thought of a chicken's egg as a cell. Can we take this up again tomorrow after school when I have more time? I need to hurry and pick up my daughter from day care. Thanks for your help.*

Mr. Thanos waved goodbye to Mrs. Jones as she left the room. He sat quietly, reflecting on how times have changed since he began teaching. Back then, it seemed that new teachers went through a lengthy teacher education program with a full semester of student teaching. Also, new teachers spent more time after school planning and preparing for the next day's classes. There were no cell phones and rushing off to take care of personal matters until long after students left for the day.

Aims of the Chapter

Use the questions that follow to guide your thinking and learning about planning to teach science:

- Why is planning so important?
- What are the major aspects of planning to consider when making decisions about a course, a unit, or a lesson?
- What are the basic components of a science lesson plan?
- How good are you at writing instructional objects for science lessons?
- Can you plan a science lesson that will engage your peers in the science methods class or students in a middle or high school in a manner that will help them to understand the methods and products of science?

Planning is one of the most important teaching functions. This activity provides a "game plan" of what to teach and how to teach. The process of thinking through a lesson gives you opportunities to sequence instructional events that hold the potential to initiate and sustain learning. Architects use blueprints, conductors follow music scores, and teachers use unit and lesson plans. All teachers plan. However, some plans are more carefully and thoroughly conceived than others.

Those who plan well will likely be more effective in helping students to learn. These teachers will be in a better position to specify learning outcomes that all or most students can achieve. They will be prepared to manage a learning environment where students are expected to be more responsible for their own learning. Further, teachers who plan well can teach for understanding rather than for covering material and rotely memorizing terms.

The most critical ingredient in planning is *time to plan*. Without taking the time to find a quiet place to think about a unit or lesson, it is unlikely that a teacher can orchestrate a coherent set of activities that will engage most students in learning. In this busy, hectic society many beginning as well as experienced teachers seem too occupied with after-school activities to devote the time necessary to meet the challenges of today's educational system. Some teachers have a second job, church activities, young children to care for, coaching duties, cheerleading practice, and so on, all of which detract greatly from planning and teaching.

In addition to after-school and extra-curricular activities, there are related in-school tasks that take away from planning. The paperwork required by the administration can exhaust most teachers. Special provisions must be *provided* and *documented* to show that each special education student is being accommodated by lesson plans that will aid him or her to achieve a given set of learning outcomes. This additional planning also is required for English as Second Language (ESL) students. The amount of testing and student progress reporting has become burdensome for all teachers. The list of noninstructional tasks that face teachers is large and growing, and for these reasons we cannot overemphasize the importance of being prepared when the bell rings to begin class.

An experienced teacher can play a big role in providing an inexperienced teacher with emotional support and ideas for successful planning and teaching. Veteran teachers have acquired curriculum resources that work well in the classroom. They have laboratory exercises, simulations, demonstrations, CDs, PowerPoint presentations, videos, textbooks, Web sites, reviews, tests, and so on, that an individual who is new to teaching must access and incorporate into his or her planning. It is not unusual for a new or even an experienced science teacher to feel isolated (Guarino & Watterson, 2002).

Therefore, it is necessary for new teachers to reach out to those who have been teaching for many years and ask for their assistance with regard to resources, policies, and things to avoid.

The purpose of this chapter is to help plan science lessons that engage students in learning fundamental science concepts in a "stand-up and teach" classroom situation. Laboratory and a more inquiry-based type of instruction will be taken up later in this textbook. Let's begin to organize our thinking about planning for instruction by using the following scheme:

- *What* are you planning to teach?
- *Whom* are you planning to teach?
- *How* are you planning to teach?
- *How* are you planning to manage the learning environment?
- *When* are you planning to assess learning?

What Are You Planning to Teach?

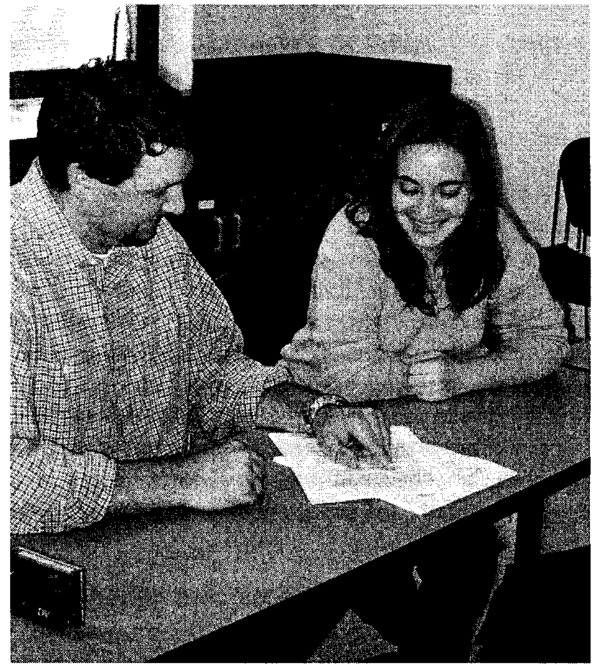
"When you plan to teach science, just what are you planning to do?"

This question is central to the planning process. When you know what to teach, you are on your way to an effective lesson. First, you must possess the type of mindset that this textbook is attempting to help you develop. Ask yourself: What is the purpose of general education in the United States? If the purpose is to train all students to become scientists or engineers, then you will probably aim to teach a high-powered science course, covering large amounts of subject matter and requiring students to work many word/math problems. If the purpose is to educate all students so that they understand certain fundamental science concepts and develop an understanding of the scientific enterprise, then you will carefully select subject matter and skills for students to master.

The vignettes that open each of the preceding chapters provide examples of the thoughts and beliefs of inexperienced science teachers whose first instinct urged them to cover a large number of abstract science concepts that were presented to them in college science courses or that are presented in a science textbook. If that is your orientation, stop and think! The chances are high that the students in the classes you will be assigned to teach will have a large range of abilities. Some common statements from beginning science teachers regarding the abilities of their students include:

- "What did they teach these kids in science in the earlier grades? They cannot graph."
- "I overestimated the ability of these kids. I thought they could use fractions."
- "Most of my students flunked the first test and I made it so easy."
- "My students are not able to write a coherent paragraph."

Lesson plans reflect the beginning teacher's best intentions for her teaching and her student's learning.



Let's recall the opening vignette in Chapter 1 where Ms. Longorio attempted to begin the acids and bases unit by getting right into pH, acid-base theories, and disassociation. When this approach did not work well, the mentor teacher suggested that Ms. Longorio begin at a more concrete level with properties of acids and bases that the students can observe firsthand. In the opening vignette in Chapter 2, Mr. Clark, the aerospace engineer, was eager to jump into some heavy-duty problem solving with his sixth-grade students until his mentor teacher came to the rescue. Ms. Roberts awakened Mr. Clark to the type of students in their middle school and the purpose of the American educational system.

While we do not want to paint a bleak picture of all students and teaching situations in the middle and secondary schools, we want to inform you of what you can expect in many teaching situations. Most people going into teaching either disregard the recommendations given here or do not take them seriously. Even with students who are enrolled in more advanced classes or attending private schools, you will find students who lack many basic skills. Remember, *you are teaching science for all Americans.*

FIGURE 3.1 Comparison of learner expectations that an uninformed, beginning science teacher might select to initiate the teaching of a topic versus a more informed, experienced science teacher.

Middle Level Integrated Science–Sound and Hearing

- Draw and label the structures of the outer, middle, and inner ear.
- Trace a sound wave from the outer ear to the brain and explain how a mechanical disturbance is changed into chemical and electrical impulses in the auditory cortex of the brain.
- Explain how the inner ear functions and aids humans in keeping their balance.

Or

- Demonstrate and explain how a blind or blindfolded person locates the origin of a nearby sound.
- Demonstrate and explain the difficulty a blind or blindfolded person has in locating the origin of a nearby sound with the use of only one ear to receive sound waves.
- With eyes closed or blindfolded, identify common objects, such as coins that are dropped onto a hard surface.

Senior High Level Biology–Photosynthesis and Respiration

- Trace the flow of energy during light and dark reactions of photosynthesis.
- Show the steps in the breakdown of glucose to carbon dioxide and water that occurs during glycolysis.
- Describe the important steps in the Krebs cycle, beginning with pyruvic acid and ending with ATP.

Or

- Identify and name objects that you see or come in contact with every day that are the result of energy from the sun.
- Write or recognize a basic chemical formula that represents photosynthesis.
- After extracting the chlorophyll from green plant leaves, describe what is taking place when this pigment fluoresces under a UV light.

Senior High Level Physics–Induced Electromagnetic Force

- Explain magnetic flux and how it relates to the strength of a magnetic field.
- State Faraday's law.
- Use a formula to determine the emf induced across a loop of wire or coil of wire with N loops.

Or

- Demonstrate several ways to produce an electric current by moving a loop of wire or a coil of wire across a magnetic field.
- Investigate a range of properties that may or may not affect the electric current produced—such as strength of a magnetic field, size of wire loop, number of loops, speed of motion, angle of the loop with respect to the magnetic field—and relate these findings to Faraday's law.
- Illustrate how induced electromagnetic forces are used in a variety of devices that serve society, such as generators and meters.

You should study Figure 3.1 to orient your thinking regarding what an uninformed, beginning science teacher might choose to initiate his or her teaching of a topic versus a more informed and experienced science teacher. Note the difference in the concrete/abstract nature of the subject matter given in the example of sound and hearing at the middle school level, photosynthesis and respiration at the high school level, and induced electromotive force at the high school level. Further, the approaches differ in that the second set of examples in each subject area implies more hands-on instruction.

Those who are preparing to become science teachers must be educated to teach in a different way than what they usually experienced over many years of schooling (Lederman & Gess-Newsome, 1999). They must learn about *pedagogical content knowledge* and use it in their teaching. Pedagogical content knowledge is a special amalgam of content and pedagogy that is uniquely the province of experienced teachers (Shulman, 1986, p. 8). The knowledge and skills obtained go beyond teaching basic content and explaining that content; they fuse the *what* and the *how* of instruction in a way that facilitates learning.

Following is a short checklist of resources to help you make wise decisions regarding *what* to teach when planning a science lesson or unit:

______ Course syllabus prepared by the school or district
______ Teacher and student copies of the assigned textbook, laboratory manual, and ancillary materials
______ Experienced teachers in the school building, district, and elsewhere
______ Innovative curriculum materials and other related resources
______ The Internet for all types of teaching resources and information about science
______ National science education standards

Stop and Reflect!

Working with a classmate, identify a topic that you are teaching or may teach in the future. List three or four descriptors of the content that you believe a new science teacher might use to initiate the teaching of the topic and contrast this with what a veteran teacher who has had plenty of experience in planning instruction might use.

WHOM ARE YOU PLANNING TO TEACH?

After you have a idea about what you want to teach, stop and think about your audience. You must think twice, three times, or more about the students you teach. How will these young and often immature people receive you as a teacher as well as the instruction you have planned? With perhaps over 100 students a day in your classes you can be certain that there will be many individuals you will not reach unless you plan carefully.

You must continually remind yourself that diversity is the major characteristic of the American school population, and you must deal with this variation in your planning, teaching, management, and assessment. You must think ahead and predict how students will react to your instruction, especially those who are limited in their speaking, reading, writing, mathematics, and study skills. Also, how will you deal with boys and girls who do not participate in instruction because they do not care about school? Will there be students in your classes who are unable to hear you speak or unable to read what you are writing on the board or projecting on a screen? How will you react to students who enjoy being disruptive and those who are poorly mannered?

Let's think about the realities of the classroom and reflect on the following questions as they relate to your selection of content and instruction for a given group of students:

Language Skills

- How will you teach students who have recently arrived in the United States from Mexico, Brazil, Russia, Romania, China, Korea, and so on, who barely speak English?
- How will you alter your instruction for students who have been in the American school system for many years, yet are unable to read at grade level and unable to write a coherent paragraph?
- How will you plan lessons that require the use of simple mathematical formulas to solve word problems for students who cannot master basic algebra?

Classroom Behavior

- What behavioral problems should you anticipate when instructing many students each day?
- How will you react to students who thrive on being disruptive?
- How will you help students take responsibility for their own learning?

Physical and Learning Challenges

- How will you modify your teaching plans for students who have difficulty seeing the board or projection screen?
- How will you accommodate students with hearing problems?
- Can a dyslexic or attention-deficit student be successful in your class?

Cultural diversity and student attributes will be discussed in more detail in later chapters. Nevertheless, these factors should be considered in your planning to teach science.

HOW ARE YOU PLANNING TO TEACH SCIENCE?

Effective teaching is a complex act that must be based on thoughtful planning and good decisions. If you observe an effective science teacher in action, you will be able to observe certain behaviors that facilitate learning. Figure 3.2 presents a menu of teaching skills, strategies, and techniques that hold great promise for engaging students in thinking and learning. Let's briefly review these aspects of teaching in order to set the stage for planning science lessons that will be taken up later in this chapter.

FIGURE 3.2 A menu of skills, strategies, and techniques to engage students in teaching and learning science for understanding.

Employ Many Teaching Skills
- ✓ Introduction
- ✓ Directions
- ✓ Questions
- ✓ Feedback
- ✓ Closure
- ✓ Assessment

Use a Variety of Instructional Strategies
- ✓ Lecture
- ✓ Discussion
- ✓ Demonstration
- ✓ Laboratory work
- ✓ Reading
- ✓ Writing
- ✓ Group work
- ✓ Simulations/games
- ✓ Recitation

Incorporate Techniques to Enhance Learning
- ✓ Note taking
- ✓ Identifying similarities and differences
- ✓ Graphic organizers
- ✓ Practice
- ✓ Reviewing

You must organize your lesson plans to include many *teaching skills* (see Figure 3.2). The plan must have a useful beginning and ending. The introduction must gain students' attention and give them an idea of what the lesson is about. The most problematic aspect of teaching a lesson is the assessment of learning because the end of the class period invariably comes before one can determine what has been learned. Then, there are the questions to be asked during the lesson, which must be planned beforehand so that they are in one's mind, ready to draw students into the learning process at any instant. The art of preparing and asking questions is based on how much you know about the topic at hand and how well you state that knowledge. Feedback during the lesson and closure also are critical components of a science lesson.

We cannot overemphasize the importance of using more than one *instructional strategy* during a class period. An instructional strategy is the manner in which a major segment or an entire lesson is approached. The experienced science teacher often uses several strategies to gain students' attention and to keep them involved in learning (Rosenshine, 2002). They move smoothly from one type of instruction to another. These teachers have learned that to use one strategy during a class period, such as a PowerPoint lecture, is not as effective as using two or more strategies. Consequently, experienced science teachers divide the class period into two, three, or even four segments and combinations of strategies that best facilitate the learning of a particular topic. In Figure 3.2, we have listed many instructional strategies that you must use in your teaching in order for it to be effective.

Educational researchers have learned that it requires more than teaching skills and instructional strategies to facilitate content mastery of subject matter. They have assisted the profession greatly by identifying many learning *techniques* that have shown to increase student achievement (Marzano, Pickering, & Pollock, 2001). For example, note taking, identifying similarities and differences, graphic organizers, practice, reviewing, and explaining are among some of the most powerful techniques to enhance learning in any course. These techniques must become part of your repertoire of teaching and must be built into your planning.

How Are You Planning to Manage the Learning Environment?

Almost every beginning teacher experiences classroom management problems. While thorough planning will eliminate many management problems, it will not ensure that all students will be on-task and behaving properly. As you plan instruction, begin to reflect on at least these aspects of classroom management:

- Creating a positive learning environment
- Managing students to learn
- Dealing with student misbehavior

Is your lesson planned so well that you will be able to interact with the students during the instruction? Effective teachers know all of their students by name and call on them to answer questions and to take part in the instruction. They have high expectations and communicate this to the students. These teachers focus on the students they are teaching as well as the subject matter they wish students to master.

Can you visualize the classroom setting where the instruction will take place? Think about the seating arrangement, the laboratory benches or tables, the writing board, projection screen, and where you will position yourself throughout the lesson. These considerations and other aspects of the instructional environment should facilitate the learning that you envision for the students. And, of course, be sure to have all of the materials on-hand and ready to go before the lesson is to be taught.

Later in this textbook you will find a complete chapter devoted to managing the science learning environment. However, you might give some thought to dealing with disruptive students and how you would react to individuals who horse around during lessons. Will you ignore this type of behavior, signal students to stop, move closer to them, speak directly to the situation, send the students to the office, or take some other action? Your goal is for the entire class period to run smoothly.

When Will You Assess Student Learning?

All lessons must include assessment. Although we often think of assessment as a test that comes at the end of a lesson or unit, assessment should occur frequently throughout the lesson as well as at the end. Effective assessment provides the teacher and students with information concerning how well learning is taking place, which in turn can be used to modify the instruction and gauge teaching effectiveness.

Your effectiveness as a science teacher can improve by using alternative as well as traditional assessment techniques, some of which are listed here:

Traditional Assessment Techniques

- Paper-and-pencil tests
  - — quizzes
  - — tests
  - — exams

Alternative Assessment Techniques

- Performance tasks
- Word problems
- Graphic organizers
- Observations
- Interviews
- Journals

Before studying assessment in more depth in a later chapter, you must consider using some of the techniques just listed in the closure and review of a lesson that you will be planning to teach during this methods course and for teaching students in middle and high schools. Effective teaching should have a beginning, a middle, and an end.

Constructing Instructional Objectives

Instructional objectives are an integral part of a lesson plan and should specify the learning outcomes for a particular national, state, or school district curriculum standard. These succinct statements zero in on what the learner should know and be able to do as a result of the teaching and learning process. Instructional objectives provide a focus for what is to be taught and what is to be assessed. Some educators refer to instructional objectives as performance objectives; others call them behavioral objectives. Regardless of the name, most educators agree that instructional objectives should be an essential component of any teaching plan.

Instructional objectives can be placed into three categories or domains—cognitive, affective, or psychomotor. Objectives in the cognitive domain relate to intellectual abilities and skills such as recognition, recall, comprehension, and problem solving. Most of the objectives in science course work are written in the cognitive domain. Objectives in the affective domain relate to attitudes, interests, beliefs, and values. Objectives in this area are beginning to appear more frequently in science curricula because they relate to critical aspects of school learning. Objectives in the psychomotor domain reflect motor skills and hand-eye coordination. They occupy a special place in the teaching of science, especially in the laboratory.

A good instructional objective must describe a learning outcome that states what the student will be able to do, know, or believe as a result of the instruction. This must not be confused with an instructional activity that indicates what students will be doing during a lesson. For example, engaging students in a laboratory exercise on constructing parallel circuits in order to learn how to wire this type of electrical circuit is not the same as asking students to solve word problems to calculate the current in different branches of a parallel circuit. One way to understand what is meant by a learning outcome or an instructional objective is to determine what students should be able to do, think, or know as a result of the instruction. The teacher should then write these outcomes in precise terms. The teacher should keep in mind several criteria when constructing objectives:

- Center the ideas to be learned on important or critical subject matter content
- Focus on student learning outcomes rather than instructional activities
- Describe what the learner should know, be able to do, or believe
- State learning outcomes that are observable
- Construct objectives that can be measured by a test or other assessment tool

Robert Mager (1984) provides a useful technique to prepare and analyze instructional objectives. He indicates that clearly stated instructional objectives have three characteristics:

1. A *performance* component that specifies an observable behavior that the learner is to exhibit.
2. A *condition* component that specifies the conditions under which the learner will be assessed and what the learner will be given or denied.
3. A *criterion* component that specifies the minimal level of acceptable performance that the learner will be expected to exhibit.

When you use the three component parts, you will most likely produce clear statements of the learning outcomes that are expected of students, which can be used to guide instruction and assessment. In practice you will find that most objectives written by science teachers for daily lesson plans include only the performance component. However, these objectives can be clarified in many instances by including condition and criterion components that will more precisely identify what it is that the students should be able to know and do as a result of the instruction.

Consider a lesson to teach students about chromosomes. Following are two example of objectives. The first is a general objective or state standard. The second is much more specific and understandable; it is called an instructional objective.

> Students should understand the relationship between the macrostructure of chromosomes and the health of humans.

The first question to ask yourself when translating a general objective, such as the one previously stated, into a more specific instructional objective is: What is it that the learner should know about chromosomes? Let's examine the following instructional objective to determine if it includes the three component parts of a clearly stated learning outcome:

> Given a karyotype to examine from a person who has several chromosomal abnormalities, identify one chromosome that indicates translocation has occurred and one that indicates deletion of genetic material has occurred.

In this example, the learner must identify chromosomes that show where genetic material has been broken off from one chromosome and relocated on to another chromosome (translocation) and where chromosomal material has been broken off and lost (deletion), both of which illustrate mechanisms that result in serious physical abnormalities.

The instructional objective stated has the three parts that a clearly written instructional objective should contain. The verb "*identify*" is the *performance* to be exhibited by the students. The phrase "*Given a karyotype to examine from a person who has several chromosomal abnormalities*" is the *condition*, or what the students will be given during their assessment of the learning outcome. The phrase "*one chromosome that indicates translocation has occurred and one that indicates deletion of genetic material has occurred*" specifies the *criterion* component for assessing student performance. How would you judge the clarity of this instructional objective?

There is one other aspect of instructional objectives that science teachers should consider. How *educationally important* are the objectives that students are expected to achieve? Do the instructional objectives suggest that students will be learning skills and acquiring information useful to their lives? We often see instructional objectives that indicate students will be learning long lists of vocabulary terms, which suggests that they are required to learn science topics in needless detail and to regurgitate this knowledge on long paper-and-pencil tests—a recipe for poor science teaching.

Stop and Reflect!

Evaluate the instructional objectives listed here with respect to their (a) clarity and (b) science education importance. For those that are not clearly stated, alter them to include the three component parts: performance, condition, and criteria.

1. Given actual items or pictures of household cleaning products, estimate their pH to within at least two units of their actual pH values.
2. Name the elements of the periodic chart.
3. Find areas of low and high pressures and cold and warm fronts on weather maps.
4. Write a report on stem cell research.

Examples of Science Lesson Plans

This section will describe three types of lesson plans—those that go into the daily plan book, the short-form, and the long-form. Each type has its own purpose. Nevertheless, the more detailed long-form will be stressed because of its usefulness to beginning science teachers and those preparing to teach science lessons for feedback in teacher education programs.

There is no one accepted format for designing a lesson plan. The sequence, number of elements, and amount of detail in a lesson plan vary considerably. The short-form lesson plan incorporates more detail than that found in the daily plan book. It is usually about one page in length. In contrast, the long-form lesson plan describes all aspects of each lesson in detail, including the handouts, worksheets, and assessments. It contains many pages and gives great detail.

The long-form lesson plan is much more useful than the short-form to analyze and reflect upon the potential effectiveness of an instructional plan. The long-form plan is very helpful for those who wish to develop and teach exemplary science lessons. Whether using the short- or long-form, teachers should recognize that a lesson plan represents their best intention of what should occur during a lesson to achieve the desired learning outcomes. From this perspective, a lesson plan should be viewed as a guide for teaching, not as an inflexible set of rules and procedures that must be followed.

Daily Plan Book

Many school districts require teachers to keep a daily plan book. A daily plan book is often confused with a daily lesson plan, which it is not. The plan book merely presents a sketch of what will occur during each lesson. It provides the minimum detail and number of elements. Usually, school districts require the teachers to briefly outline their teaching plans for each week. This gives the teacher, administrators, or a substitute teacher some idea of what should be taught each school day. Figure 3.3 is an example of a daily plan book for five class sessions of a unit on chemical names and formulas. These lessons are intended for high school chemistry students. Inspection of the example reveals that space is limited to describe the elements associated with the lesson. The elements contained in this particular plan book are as follows: abbreviated instructional objectives, procedures, resource materials, and evaluation. Because so little information is given in the plan book, it is difficult to determine exactly what will take place during the lesson and to critique it for its potential success.

FIGURE 3.3 Daily plan book for 1 week of instruction.

Monday

Instructional Objective: Explain the organization of the periodic table.

Procedure: Students read and discuss Section 5.1 "The Periodic Table." Students locate groups, periods, representative elements, and transition elements.

Resource Materials: Addison-Wesley's *Chemistry:* Chapter 5, pp. 107–108. Transparency of Period Table.

Evaluation: Have students explain how properties of elements vary from the one side of the chart to the other and from top to bottom.

Tuesday

Instructional Objective: Define cation and anion and describe how they are different.

Procedure: Teacher demonstration, 5.2 "Ionization of Sodium Metal." Students discuss demonstration and the production of ions.

Resource Materials: Addison-Wesley's *Chemistry* (*TE*): Chapter 5, pp. 106B. Na metal, 0.1% phenolphthalein, safety goggles for all students.

Evaluation: Have students explain how the magnesium ion differs from a magnesium atom and how a bromine ion differs from a bromine atom.

Wednesday

Instructional Objective: Distinguish between chemical formula and molecular formula.

Procedure: Students view the video *Chemical Symbols: Formulas and Equations* and practice writing chemical and molecular formulas.

Resource Materials: Videocassette player and monitor video #4FS.

Evaluation: Provide chemical and molecular formulas and ask what information can be obtained from the formulas.

Thursday

Instructional Objective: Infer the charge on an ion from the periodic table.

Procedure: Students construct a table of ionic charges of representative elements by group.

Resource Materials: Transparency of Period Table.

Evaluation: Have students name the ionic charge of an element when given its group.

Friday

Instructional Objective: Learn the names and formulas of polyatomic ions.

Procedure: Students read and discuss Section 5.7 "Polyatomic Ions." Students construct models of polyatomic ions and ion complexes.

Resource Materials: Addison-Wesley's *Chemistry* (*TE*): Chapter 5, pp. 122–123. Polystyrene balls of various sizes, toothpicks.

Evaluation: Have students match the names and formulas of 3 polyatomic cations and 3 polyatomic anions.

Based on information from Chemistry, *by A. C. Wilbraham, D. D. Staley, and M. S. Matta, 1995, Menlo Park, CA: Addison-Wesley.*

FIGURE 3.4 A short-form lesson plan pertaining to wind and weather.

Class: Earth Science, Section II
Unit: "Wind and Weather"
Topic: Weather Vanes

Instructional Objectives: Students should be able to:

1. Construct a weather vane using simple materials.
2. Determine wind direction using a standard weather vane and a compass.
3. Describe how the size and shape of the weather vane's point and tail affect its operation.

Time	Activity
9:15–9:25 A.M.	Use color slides of different weather vane designs to introduce the topic of weather vanes. Ask students: Does changing the size and shape of the point and tail of a weather vane affect its operates? Record student predictions.
9:25–9:40	(*Exploration*) Give instructions regarding use of the compass and have student groups construct several standard weather vanes with the following features: (a) large point and small tail, (b) small circle and large circle in place of point and tail, and (c) squares of the same size in place of point and tail.
9:40–9:50	Students test the different wind vanes and record their results on an activity sheet. Use blow dryers as a wind source if winds are calm.
9:50–10:10	(*Intervention*) Class discussion of results. Guiding questions: How are the compass and weather vane used to determine wind direction? How does the shape and size of a weather vane's point and tail affect its performance? What rule can we state about the performance of weather vanes based on our work?

Assignment

1. (*Application*) Construct a weather vane different from the ones constructed in class. Does its performance provide support for our rule?
2. Ask for volunteers to interview a friend or family member about how a weather vane works, and share the results of their interview in class.
3. Textbook pp. 205–206,"Weather Vanes and Weather Forecasting."

Activity Materials Needed

45 note cards, 15 pairs of scissors, 15 pencils with erasers, 15 straight pins, 15 compasses, 3 blow dryers, 3 rolls of transparent tape

Resources for Lesson

1. Weather vane slides
2. Teacher-made activity sheets
3. Bulletin board with pictures of weather vanes

Short-Form Lesson Plan

The short-form lesson plan includes a moderate amount of detail about a lesson. Figure 3.4 shows an example of a short-form lesson plan about weather vanes that is part of a junior high school earth science unit on wind and weather. It also shows the teacher's intended use of the learning cycle model to have students explore different weather vane designs and to construct an understanding of the important features of a weather vane by means of discussion.

Analysis of this example reveals the advantages and disadvantages of the short-form lesson plan. The time schedule gives the teacher an idea of what to do during each time segment of the class period. This will help the teacher gauge the length of each activity and realize how much can be accomplished during the period. There is plenty of room in this lesson plan to write the assignment, list the materials that are needed, and mention the references that will be used.

This type of plan has two major shortcomings. First, the objectives are usually abbreviated in that only the performance component is given, and the conditional and criterion components are left out because of space constraints. When the conditional component of

an instructional objective is omitted, the conditions under which the students will be assessed are not revealed. Using this form, it would be difficult to describe the lesson's beginning, the major instructional activities, the directions for weather vane construction, or the closure. It is possible to provide the necessary detail for these elements, however, by adding additional pages to describe these activities more fully.

Long-Form Lesson Plan

The long-form lesson plan is a complete and detailed plan of instruction that includes many elements. An example is presented in Figure 3.5. The plan may be many pages and provides a thorough description of the instructional plan: purpose, objectives, activities, and so forth. The long-form gives the teacher an opportunity to formulate a thorough and meaningful plan of instruction. This type of plan is often used in teacher education programs because it can be analyzed to determine the extent of the preparation, appropriateness of the activities, the relevance of the learning outcomes, and the continuity among lesson plan elements. The long-form format is ideal for designing a lesson to stimulate student interest and to achieve specific learning outcomes that can be analyzed to determine the extent to which these aims might be attained or have been attained at the conclusion of the lesson. There is no accepted format for the number of elements and the amount of detail in a long-form lesson plan. The following list suggests elements that the teacher might incorporate in a thoroughly prepared science lesson plan:

- Title
- Purpose
- General Objectives
- Instructional Objectives
- Major Concepts
- Materials and Equipment
- Instructional Activities
  - Introduction
  - Other instructional activities
  - Review
- Assessment of Instructional Objectives

By now, you should realize that planning to teach science requires a great deal of effort, but without it your teaching effectiveness will suffer, as will your ego. The more you practice detailed lesson planning, the easier it will become and the better you will teach. Continue on to the Assessing and Reviewing section of this chapter to reinforce your understanding and ability to plan good science lessons.

FIGURE 3.5 An example of a long-form lesson plan highlighting certain components of this type of instructional organization.

"Why the Nerve of You"

Improving Your Mind and Mood by Better Understanding
Nerve Cell Function, Receptors, and Nutrition

Purpose

How you think is critical to how you live. But what does this have to do with biology? Human behavior is centered in biological cells. If this is true, then gaining insight into the structure and function of nerve cells can provide useful knowledge about behavior and well-being.

During this lesson, we are going to begin the study of the cell. However, instead of focusing on the structure of the cell and naming all of its parts, we will begin by examining cellular structures and functions that can add greater meaning to cell biology because of their relevance to everyday living and immediate application of learning. For example, how would you like to learn how to influence your brain in order to get to sleep faster or to energize your thinking so that you are a better problem solver?

State Standard and General Objective

Learn about the structure and function of different types of plant and animal cells.

Instructional Objectives

1. Explain the function of neurotransmitters in facilitating communication between nerve cells. [Assess during the lesson.]
2. Describe and identify the predominant macronutrient (carbohydrate and protein) in common food products and indicate which neurotransmitter (dopamine, norepinephrine, and serotonin) it releases from the axon tip of a nerve cell. [Assess during lesson and at the end of lesson.]

(Continued)

FIGURE 3.5 Continued.

3. Briefly describe or state the specific effect that each macronutrient (carbohydrate and protein) has on mental awareness—that is, whether the macronutrient stimulates or relaxes the mind. [Assess during and at the end of lesson.]
4. Given a diagram and major parts of two adjacent nerve cells, trace the movement of three neurotransmitters—dopamine, norepinephrine, and serotonin—across the synapse between two adjacent nerve cell endings. [Assess during lesson.]
5. Form a spherical model of a cell with modeling clay and create a variety of unique indentations on the surface of the cell to represent molecular receptors. [Assess during lesson.]
6. Create two menus or meal plans, one that will energize you and one that will relax you (which will be used over a 1-week period), reporting the results to the class. [Assess during lesson.]

Major Concepts

Nerve cell, receptor, neurotransmitter, macronutrient, mental stimulation, and relaxation.

Instructional Materials

[This information has been eliminated due to space considerations.]

Instructional Activities

1. Set induction. Engage the audience in the lesson by placing two foods on the demonstration table. Food A should be a carbohydrate and Food B a protein. A box of spaghetti and a can of tuna fish will do.

   Present the scenario: You have had a very hard day at work. There were many problems to solve and you had to stay until 6:30 PM before leaving for home. You will be eating supper at 8 PM, much later than usual and hope to be in bed by 10 PM, because you have to be at work in the morning by 6 AM

   Q: What would you choose to eat for supper in order to fall asleep as soon as possible and perhaps to get a good night's rest?

   Ans: You should *not* eat too much, and you should eat plenty of carbohydrates with modest amounts of protein. **First,** eating too much may keep you awake, as your digestive system may have to work hard to do its work. Eating too much protein might give you too much mental energy and interfere with getting to sleep in less than 2 hours after a meal. **Second,** carbohydrates have a relaxing effect on your mental state and may assist you in winding down after a hard day at work and help you to fall asleep.
2. Place the title of the lesson on the board "Why the Nerve of You." Cover the title with a **sheet of newsprint** and remove it for effect. Give the purpose of the lesson by presenting the information in the **Purpose of the Lesson** on the first page of this plan, followed by the **Instructional Objectives.**
3. In order to better comprehend brain chemistry and how foods and drugs lead to specific responses in our body, let's examine the diagram of the nerve cell shown in the **transparency** with **copies to students.** Pass out a nerve cell diagram to all students.

   Discuss the movement of nerve impulses along the axon:
   a. electrical impulses move along the axon to the axon terminals,
   b. the axon terminals release neurotransmitters that move across the synapse to receptors on the surface of nerve cells (dendrites) or muscles cells, bones cells, or intestine cells, etc., and
   c. the receptors that act as on/off switches for specific responses.

   Direct the students to draw a chemical mechanism that illustrates what takes place at the axon terminal tip/synapse/receptor junction.

   Ask many questions to make this information more relevant to students:
   a. What happens neurologically when you eat a hamburger? (Stimulates brain activity.)
   b. What happens in your body when you take in an opiate like cocaine or eat chocolate? (They make you feel good.)
   c. What happens when you take an antihistamine? (Blocks allergic reactions via receptors.)

4. Let's continue the study of brain chemistry by examining two contrasting types of neurotransmission with the use of an overhead transparency.
   → energizing mind/body responses
   → calming mind/body responses
   a. When you eat a protein-based meal, the resulting composition of the blood is such that the amino acid *tyrosine* enters the brain, which in turn initiates the release of the neurotransmitters *dopamine* and *norepinephrine*. This series of chemical reactions produces an energizing effect.

      Protein → tyrosine → brain → **dopamine & norepinephrine** → energizing effect

   b. When you eat a carbohydrate-based meal, the resulting composition of the blood is such that the amino acid *tryptophan* enters the brain, which in turn initiates the release of the neurotransmitter *serotonin*. This series of chemical reactions produces a calming effect.

      Carbohydrate → tryptophan → brain → **serotonin** → calming effect

5. More information about the chemistry of tryptophan and tyrosine. [The rest of this activity has been eliminated due to space considerations.]
6. Ask participants to draw, label, and give the function of the major structures associated with neurons. [The rest of this activity has been eliminated due to space considerations.]
7. Stress the importance of **receptor molecules** that reside on the surface of cells. Neurotransmitter molecules dock onto receptors molecules, which convey chemical messages to the cells, be they nerve or other type of cells of the body (muscle, bone, immune, digestive). Distribute a small piece of **modeling clay** to each participant.

   Directions: Form the clay into a ball to represent a cell. Using a pen, pencil, coin, key, or any small object, make indentations on the surface of the cell model to present different chemical receptors.
8. Pass out to everyone a four by six index card. Instruct the class to draw a line down the middle of the card. **Create two meal plans:** (a) one that will energize you and (b) one that will relax you. These meals can be for breakfast, lunch, or dinner. Experiment with the meals several times over the next week and bring back the findings for discussion.

Review of Lesson

a. Form groups of two to four participants. Ask them to draw a diagram or a concept map to illustrate the connection among: various types of foods or macronutrients, the nervous system, and mental moods.
b. When the groups have completed their visuals and placed them on large newsprint paper, display and discuss them. Focus the discussion on the instructional objectives of the lesson and present on an overhead transparency the concept map designed for this lesson.

Post-Lesson Assessment of Selected Instructional Objectives

1. Identify the predominant macronutrient (carbohydrate and protein) in common food products and indicate which neurotransmitter(s) (dopamine, norepinephrine, and serotonin) it releases from the axon tip of a nerve cell.

Food Product	**Macronutrient**	**Neruotransmitter**
Rice	____________	____________________
Steak	____________	____________________
Tuna fish	____________	____________________
Potato	____________	____________________
Corn	____________	____________________

2. State the specific effect that each macronutrient (carbohydrate and protein) has on mental awareness (i.e., whether the macronutrient stimulates or relaxes the mind).

Assessing and Reviewing

Analysis and Synthesis

1. Consider a science lesson that you might conduct with your peers in the methods class. Write three or four instructional objectives that include a performance, condition, and criterion component. Exchange your list with others and analyze each instructional objective for relevance to the audience and for the inclusion of the three component parts of a clearly written learning outcome.
2. Gather some lesson plans that have been developed by science teachers for their classes. Evaluate each plan for the following:
   a. Relevance for the intended student audience.
   b. Inclusion of important components of a teaching plan, for example, title, purpose, instructional objectives, instructional activities (introduction, variety of activities, questions, review, closure, and assessment).
3. Evaluate the long-form lesson plan example shown in Figure 3.5. Use the component parts of a teaching plan to guide your assessment of the plan.

Practical Considerations

4. Construct a checklist of reminders that you will incorporate into your lesson planning. Organize the list by using the headings that follow. For each heading add several phrases.

   What am I planning to teach?

   Whom am I planning to teach?

   How am I planning to teach?

   How am I planning to manage the leaning environment?

   When am I planning to assess learning?
5. Design a long-form lesson plan to be given to the participants in the methods class. The plan should be 50 to 60 minutes in duration, and it should be aimed at teaching the adult science majors some aspect of science that they are not familiar with or have not understood in preparation for becoming a science teacher. The lesson plan should be interesting and meaningful to the participants and challenge their thinking.

Developmental Considerations

6. Identify a few science teachers who are regarded as very effective in their work. Discuss planning with these individuals and ask them for tips on how to prepare lessons in an efficient manner. In addition, ask the teachers to share with you some of their best lesson plans.

Resources to Examine

The Science Teacher, September 2002.

The entire issue is devoted to helping teachers survive their first year on the job. Here you will find: (a) tips and tricks for success, (b) lifelines to help you stay afloat, (c) organizing the classroom, (d) coping with isolation, (e) working with a mentor, and so on.

The Educator's Reference Desk. [On-line]. Available: http://www.eduref.org.

This Web site has many lesson plans written by teachers. The site continues to add lesson plans that range from art to social studies. The science lessons include topics related to agriculture, biology, earth science, natural history, physical science, process skills, space science, and technology.

"Cultural Myths as Constraints to the Enacted Science Curriculum." (1996, February). *Science Education,* pp. 223–241.

Kenneth Tobin and Campbell McRobbie's study of cultural myths identifies beliefs held by teachers that tend to inhibit them from planning and teaching in ways that support the reform initiatives. The beliefs depict constraints that are both personal and social constructions; center on the transmission of content knowledge, teaching efficiency, course rigor, and exam preparation; and have broad support among educational stakeholders, including students, parents, and school administrators.

"Those Who Understand: Knowledge Growth in Teaching." (1986). *Educational Research, 15*(2), pp. 1–32.

Lee Shulman presents his thoughts about pedagogical content knowledge—the unique knowledge base that teachers develop as a result of experience and reflection. This is a seminal paper about the special knowledge that effective teachers possess that combines knowledge about subject matter with ways of teaching that content.

Cases in Middle and Secondary Science Education: The Promise and Dilemmas. 2000. Thomas Koballa, Jr. and Deborah Tippins Eds. Upper Saddle River, New Jersey: Merrill. Go to http:www.merrilleducation.com

This paperback book contains over 30 open cases describing science instruction. Each case is written by a science teacher or science educator and followed by a reflection by a science educator. The text is an excellent resource for beginning and experienced science teachers and for those who are preparing science teachers. It serves as a companion text for this science methods textbook.

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